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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication of Bus and Railway Air Conditioning Equipment

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LUBRICATION

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Lubrication of Bus and Railway Air Conditioning Equipment

AIR conditioning in transportation is a matter of comfort cooling. Comfort heating began with the sheet iron stove located in the corner of the railway passenger coach, shortly after the golden spike was driven to link the Atlantic and the Pacific. In those days, the coaches were of wood, likewise the fuel. It was comparatively easy to maintain at least a reasonable degree of comfort in cold weather by even this crude method; and as more modern steam heating was developed, the passengers suffered even less.

They suffered more, in fact, in warm weather, especially on long overland rides in the South and Southwest, when open windows furnished but a point of entry for hot, dusty air. Then a ride of some fifty miles only was necessary to remind one of the hardships of the dust bowl.

Refrigeration, with the subsequent development of air conditioning which prevailed in the post-war era, corrected all this. Then we were able to close the windows to keep cool on our summer railroad travels and this kept out the heat and dust. Meanwhile, controlled refrigeration maintained both the humidity and temperature within the cars at the most comfortable ranges.

More recently, air conditioning (by the compression system) has been extended to bus operations, especially in service where long overland trips are involved in prevailing high temperature localities where the dust factor is equally objectionable.

THE DEVELOPMENT

Statistics show that mechanical air conditioning was first installed in railway service in 1929. There is no doubt but that it improved passenger goodwill materially. In appreciation thereof, the railroads did not hesitate to extend their installations until today there are some 12,000 air-conditioned cars in service.

The first air-conditioned bus was put in service in 1935. Today there are some 1000 units, added proof that passenger-comfort is prominent in the minds of the management.

The cost to air condition a railway diner or Pullman car or an overland bus is not an inconsiderable figure. It used to require some \$8000 per railway car for an attached compressor refrigeration system; today it is somewhat less. The cost to air-condition a bus, in turn, is from \$1200.00 to \$1800.00. Translating these figures into additional fares to develop the return on the investment is difficult. Apparently transportation Boards of Directors have not been dismayed, however, that this return will add to their dividends. At least, air conditioning has assumed as popular a relationship to passenger comfort as streamlining has to speed. Both, judiciously applied are conducive to health and a sense of security.

METHODS OF REFRIGERATION

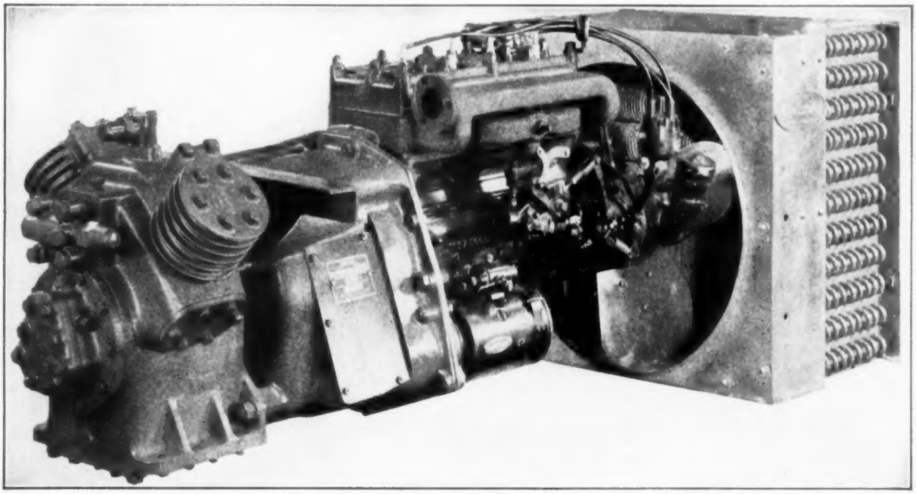
*Mechanical air-conditioning of railway cars is developed by two methods:

(1) By ice cooling whereby the air is cooled by passing around a radiator through

*Steam jet cooling is not discussed as lubrication is not essential except for motor, fan and blower bearings, where our notes on ball and roller bearings will apply.

which water (which has been ice cooled) is circulated, using ice which is packed in insulated storage boxes beneath the cars. In other words, the ice cools water sprayed thereon, the water then being

(2) By refrigeration developed at the car itself, through a unit driven compressor and condensing system. This method can be equally well applied to railway or bus service.

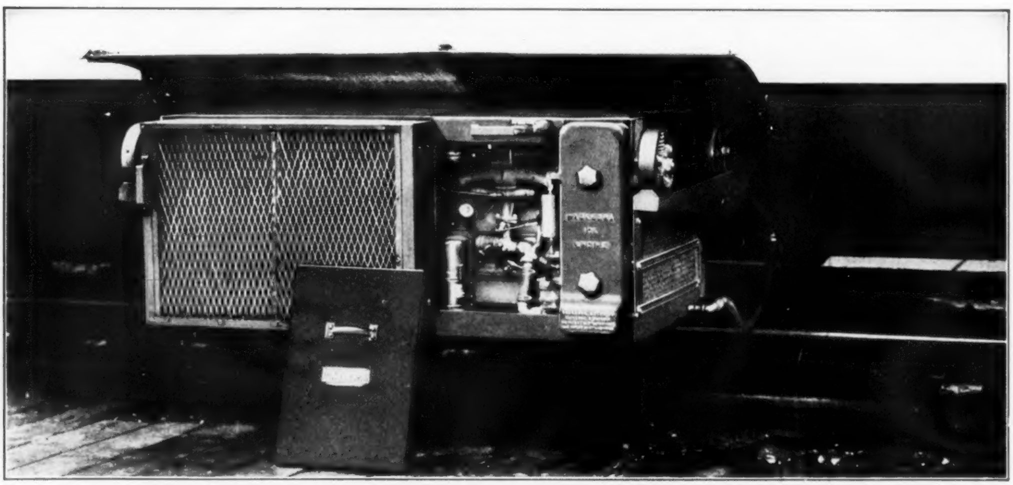


Courtesy of Carrier Corporation

Fig. 1—External side view of the Carrier compressor-engine-condenser assembly, as designed for bus air conditioning service.

circulated through finned coils in the car. Air is blown over these coils into the car to develop the desired cooling effect.

Refrigeration, of course, is necessary for the manufacture of this ice, at central



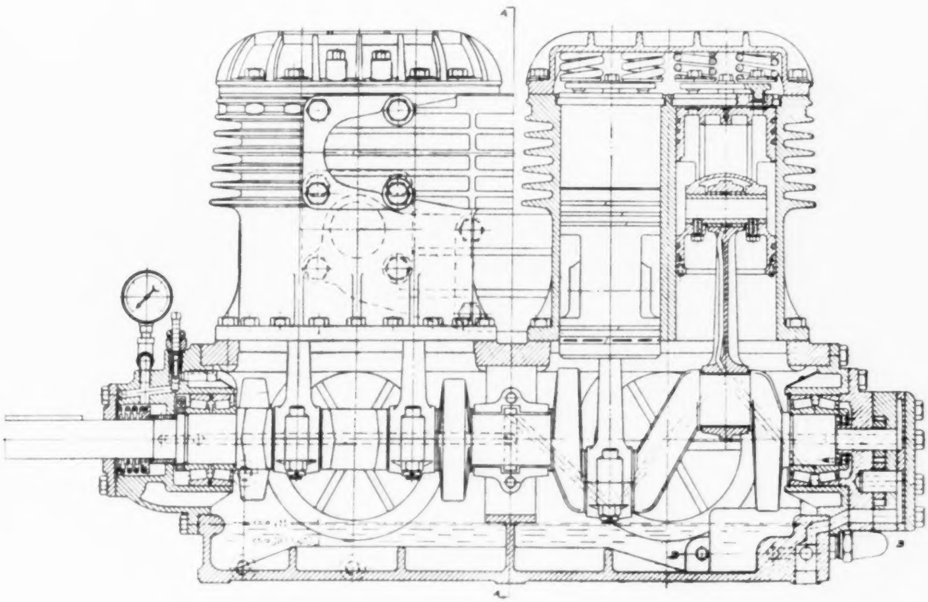
Courtesy of Waukesha Motor Company

Fig. 2—Showing how the Waukesha Ice Engine can be made readily available for inspection or maintenance by raising the side cover, when the unit can be rolled out from under the car.

refrigerating plants, from whence it can be handled to specified loading points along the line. This method is best applied to railway service.

Ice cooling furnished the basis of some of the earlier converted air-conditioned railway installations, although the first actual air-conditioned railway installation was electro mechanical. There are limitations to ice cooling, in that the available refrigerating capacity is variable, depending upon the amount of ice in the storage compartment. Any delay in reaching the next point of replenishment may be discomforting.

Both methods, however, concern the lubricating engineer, for compressor lubrication in either case is involved, requiring most careful selection of refrigeration compressor oils, likewise quality greases for circulating fan bearings. This article will deal primarily with lubrication of air conditioning and refrigerating equipment on the car or bus itself.



Courtesy of Baker Ice Machine Company, Inc.

Fig. 3—Side view details of the Baker Freoncompressor. On this unit the crankshaft is rifle drilled for full force feed lubrication to bearings, piston pins, shaft seal, and lower cylinder walls. Note oil level in the crankcase, also the use of roller bearings on the main bearing assemblies.

Compressor Design

We shall begin at the compressor, since the basic principles of refrigeration by compression are involved. Compression is the third stage of a cycle of four, which include evaporation and expansion of the refrigerant to remove or absorb heat from the surroundings, and compression and condensation, to abstract this heat subsequently from the refrigerant. This cycle is continually repeated when the system is in operation.

The rotary (vane type) compressor or the conventional reciprocating compressor, is used in bus and railway service. Lubricating oil for the former must be capable of maintaining free movement of the vanes in their respective slots. With the latter, the lubricating engineer is confronted with the problem of protecting piston rings and cylinder walls, and main, crankpin, and connecting rod bearings. Rarely, however, will extremely low temperatures prevail, so he fortunately does not have to meet the problem of possible congealment in the system should excess oil carry over to the high side. Normally any excess is recirculated, although an oil separator should remove the majority for return to the crankcase.

It is essential, however, to study the breakdown tendency in selecting the oil originally, for the presence of unstable hydrocarbons is felt to be the cause of subsequent gum formations. That is why the petroleum industry has regarded refrigeration and air conditioning as a major research problem. These gum-forming constituents can only be removed by selective refining. Research dictates the method most adaptable to the crude stocks available.

The Reciprocating Compressor

This unit is similar to the conventional commercial unit, being of either the two or four-cylinder type, designed to use a "Freon" refrigerant with provision for splash or pressure lubrication by a 300 or 500 viscosity,* high dielectric, refrigerant-grade, straight mineral oil.

The weight factor has influenced compressor designers to study methods of assembly and materials in order to reduce the weight of the finished installation as much as possible. This has been accomplished by reducing bore and stroke dimensions, and designing the modern compressor to operate at the speed of its driving engine, or at about half the speed of its

*300 or 500 seconds Saybolt Universal viscosity at 100 degrees Fahr.

motor. This is a radical departure from stationary or commercial practice where speeds are considerably lower. Authorities state that compressor weight should be about eighteen pounds per ton of refrigeration.

The Rotary Compressor

This unit is also noteworthy for its light weight. It is of the vane type, employing a number of nitralloy or stainless steel vanes, which are lubricated by a built-in pressure feed oiling system. Here the lubricant serves the bearings, and the vanes against the cylinder bore and end plates. Oil also provides a moving seal between the high and low pressure sides, and protects the rotating shaft seal.

Lubrication of the rotary vane-type compressor requires a heavier oil than the conventional reciprocating design, due to the continuous pressure, high speed, and higher temperature conditions which prevail. Normally, the manufacturers consider a refrigerant grade oil of high dielectric strength, with a viscosity range of from 100 to 125 seconds Saybolt viscosity at 210 degrees Fahr., as most suitable. Use of a lighter oil will cause noticeable reduction in volumetric and compression efficiency, with probable increase in the rate of wear.

COMPRESSOR LUBRICATION

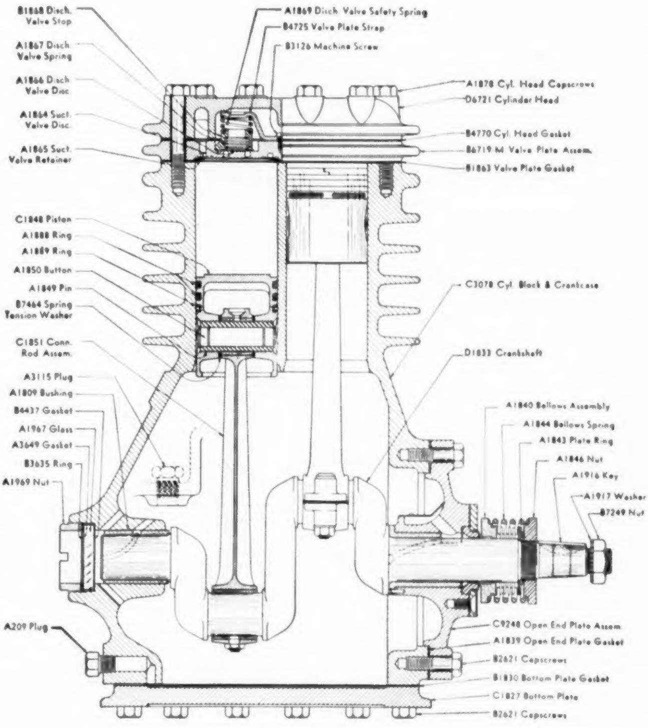
Splash and pressure lubrication are applicable to the railway or bus type of refrigerating compressor. The latter is suited for the lubrication of both vertical and horizontal machines. The former, however, is better adapted to the vertical compressor.

The system involved for the lubrication of compressor cylinders, stuffing boxes, and enclosed bearings will have a decided influence upon the grade of oil that should be used. Prevention of leakage of refrigerant is also most important; this can be accomplished by using a self-aligning, positively-lubricated seal of "Freon" resistant material.

Splash Lubrication

In a splash lubrication system, oil is distributed at each revolution of the rotating element, the level in the oil sump being maintained just high enough to permit the former to dip and splash the necessary amount of oil to the cylinder walls. Continued operation will result in the crankcase being filled with a lubricating vapor above the main body of oil, which will insure adequate lubrication of main, wrist pin, and crank pin bearings.

Careful attention is necessary, especially when recharging the case with oil, to see that the level is not raised too high. The resultant churning and violent agitation in the main body of oil would not only preclude effective precipitation of any solid impurities present, but it would also retard cooling, with boil-off of "Freon" during periods of standby. In addition, there would be possibility of excessive oil pumping past the piston rings, with subsequent entry of an excess of oil into the condensing and evaporating parts of the system.



Courtesy of General Refrigeration Corporation

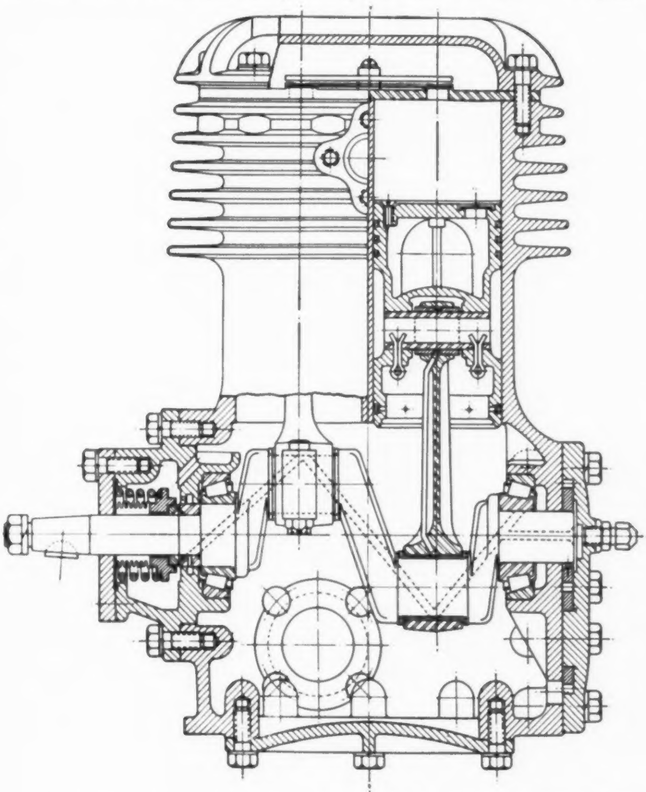
Fig. 4—Compressor details showing provision for lubrication via suitable oil ducts. Also note crankcase oil filling and drain plugs.

Splash lubrication, otherwise, is advantageous in that it obviates starved lubrication, provided the compressor parts are designed for thorough circulation of the oil after this is begun by the splash elements. All that is necessary usually is to maintain a suitable oil level to enable the splashers to dip to a sufficient extent at each throw of the crankshaft.

Piston Ring Fit

When piston rings are not sufficiently tight, however, if the crankcase contains too much oil or agitation is too violent, the excess which naturally will reach the cylinder walls will tend to work past the rings, just as so frequently occurs in an automobile engine. This is often

termed "oil pumping". This is not only wasteful, but also a detriment, for oil in the refrigerating lines will impose an added load on the oil separator. Furthermore, if by chance the oil is not of sufficiently low pour test, there



Courtesy of Baker Ice Machine Company, Inc.

Fig. 5—Cutaway view of a twin-cylinder single acting vertical enclosed compressor used in the **Baker** Bus Air-Conditioning Unit. Full force feed lubrication to all moving parts is supplied by a built-in, positive drive, high pressure gear type oil pump. Balanced type bellows shaft seal assures perfect seal under all conditions with minimum friction.

may be possibility of crystalline or amorphous wax formation at the expansion valve or restrictor, to interfere with the operation of the unit. Even with rings in good condition, oil pumping is often due to faulty design of the evaporator or careless operation, whereby liquid refrigerant enters the cylinders from the evaporator.

Use of excess oil in a splash lubricated system will also involve the possibility of difficulty when draining and cleaning, especially where sludging has taken place. Continued churning of improperly refined oils will cause sludge formation. In part, this is due to breakdown; it will be most probable where water is present, or the oil is laden with very much foreign matter, such as dirt, metallic particles, or carbon. Regular periods for inspection are therefore advisable in order to study the condition of the system. This will very often indicate conditions which may not only affect lubrication but also refrigeration capacity.

Pressure Systems

Pressure lubrication is used with marked success. Pressure assures a relatively accurate control of the amount of oil delivered to cylinder walls and compressor bearings in the reciprocating machine, and to the vane slots and cylinder wall in the rotary unit. The object is to obtain positive circulation of oil throughout the compressor, and to reduce foaming as much as possible. The latter will always be present if oil splash occurs to any extent. The degree to which it may be objectionable will depend upon the oil level and the location of the suction valves. Wherever the compressor takes its suction through the crankcase, if the foam level rises to a sufficient degree, it may be carried over to the high side with the refrigerant to cause retardation of heat transfer. Ultimately, if allowed to continue, cleaning of the system may be necessary. The attendant expense is, of course, objectionable. To obviate this, some builders have arranged their design so that all the refrigerant gases and vapor are excluded from the crankcase.

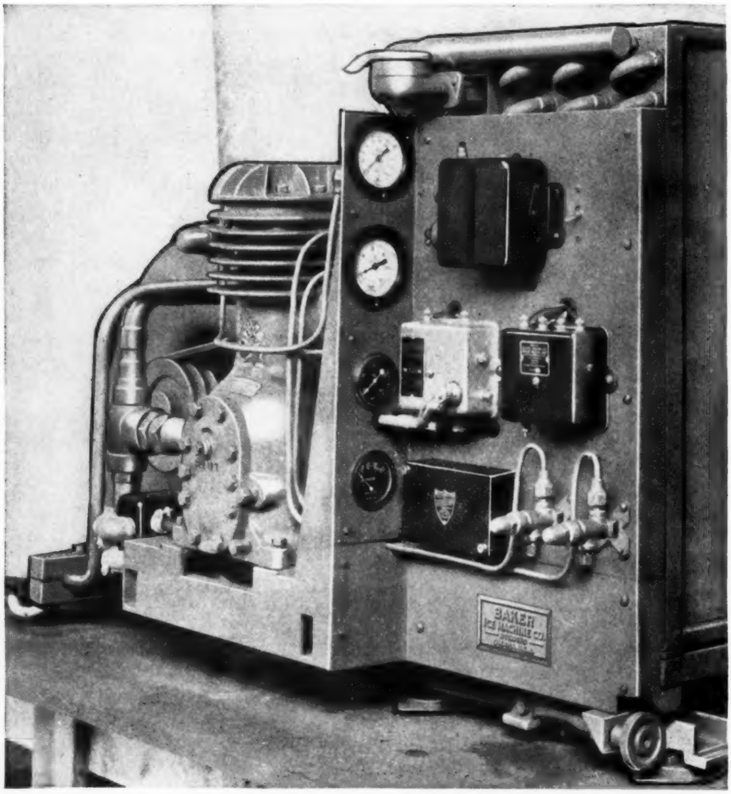
Pump Design

Today there is a definite trend towards controlled lubrication, especially where dealing with refrigerants which are miscible with mineral lubricating oils. This has required consideration of strainers and oil separators, along with pump design. All are more or less related to compressor efficiency and capacity, viz., a continued excess of oil will lead to slugging and reduction in efficiency; yet there must be a slight excess on starting to assure of positive lubrication of piston and cylinder walls, especially in the reciprocating machine. This can be assured by proper pump adjustment.

The Gear Pump

This element—an offshoot from automotive practice—has been proved to be as equally dependable in refrigerating compressor service. The gear pump, as designed for positive delivery of oil, is a comparatively simple device, consisting of a pair of gears mounted in a suitable housing. The normal location of such a pump is in the base of the crankcase of the

compressor, although some designers prefer to place this pump at the lowest part of the case. Others are of the opinion that the pump should be set just above a depression or catch basin in the case to provide means for trapping foreign matter, and preventing its being circulated through the lubricating system. Usually, however, foreign matter in a well-designed system using properly refined oil will be conspicuous by its absence.



Courtesy of Baker Ice Machine Company, Inc.

Fig. 6—Exterior view of a Baker bus air conditioning unit. Note compact arrangement of compressor and panel controls.

Irrespective of the location of the pump, however, suction is automatically maintained by gravity, since the pump is below the normal oil level. In a typical system, the discharged oil, under pressure according to the speed of rotation of the gears and their relative tooth dimensions, is led from the discharge side of the pump to the connecting rod bearings and other elements by drilled passages and suitable piping connections. As oil passes out from the bearing clearance spaces or drips from the cylinder walls or other parts of the interior housing, it returns to the case or oil sump by gravity for recirculation.

COMPRESSOR OIL CHARACTERISTICS

It has been noted that the viscosity of the oil used for compressor lubrication must be studied in conjunction with the design of the compressor, also its speed, pressure, and operating temperature. The higher the speed and temperature, the more viscous must be the oil. Thus the rotary vane-type compressor requires a heavier oil than a reciprocating machine which can normally function on an oil of 300 to 500 seconds Saybolt viscosity at 100 degrees Fahr.

As with any "Freon" system of refrigeration, however, one must also consider that miscibility of refrigerant with oil will reduce both the viscosity and pour test of the oil to a marked degree. This is not a disadvantage, for there is adequate lubricating value to the resultant mixture. Instead, it is regarded as beneficial by some, as the reduced pour test and greater fluidity lends to better separation in the oil separator; likewise, less possibility of congealment in the evaporator. So oil clogging in such a unit is rare; the design also provides for more complete return of oil to the compressor.

All this has been considered by the manufacturers in designing their units. As a result, their lubrication recommendations specify viscosity ranges or S.A.E. numbers accordingly.

It is not sufficient to consider only the viscosity or body of the oil. Refrigeration service requires equally as careful consideration of the pour test, the dielectric strength, and the stability of the oil. These are points which have been most carefully considered by the research chemist in developing methods of refinement for such oils.

High Dielectric Strength Denotes Freedom From Moisture

Refinery procedure is planned to produce finished oils for refrigerator compressors which are entirely water-free. To insure that they continue in this condition, they are packaged in sealed containers. The customer must realize

the importance of preventing moisture absorption after he breaks these seals, also the fact that but a trace of moisture will throw such an oil appreciably off test.

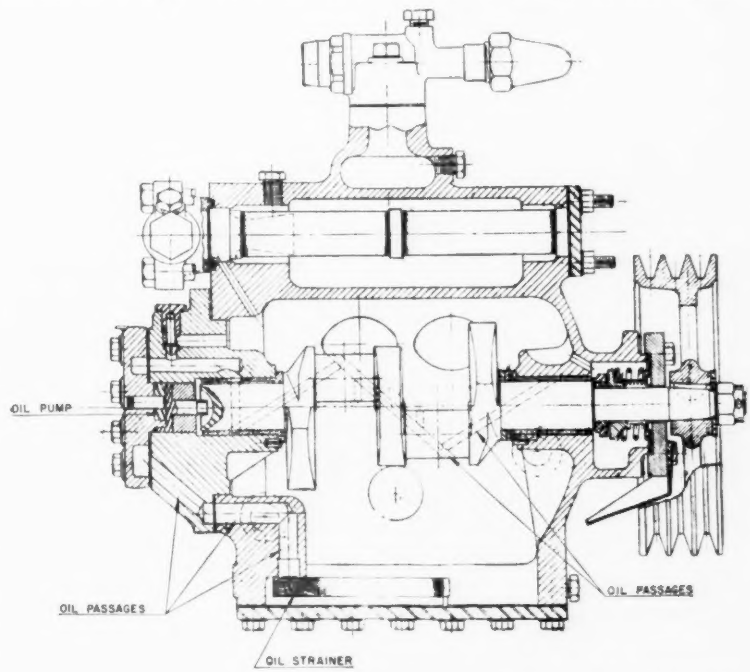
So the petroleum industry refines to a high dielectric strength—a test which originated in the manufacture of electrical transformers, but which later proved equally as valuable as an indication of the moisture content of refrigeration lubricating oils. Normally, most compressor builders specify, and refiners manufacture to, a minimum dielectric strength of 25,000 volts.

Moisture is widely regarded as the basic cause of so many of the corrosion and sludging difficulties which have perplexed the refrigerating engineer. It seems to act as a catalyst to hasten these reactions, especially when the original oil may have been susceptible to breakdown in the presence of certain refrigerants. The "Freon" group, Carrene and methyl chloride, are normally free from corrosion difficulties, as operating temperatures never become severe enough to develop corrosive acids. In fact, a temperature of over 1000 degrees Fahr. (dull red heat) would be necessary to cause such dissociation. They do, however, experience sludge formations in the presence of water.

The petroleum refiner removes moisture from compressor oils by filter press treatment, using a special grade of filter paper for moisture absorption. In this dehydrated state, however, such oils will tend to reabsorb a certain amount of moisture, according to the relative humidity and temperature, when exposed to the air for any length of time. Hence, the precaution necessary when opening a sealed container.

Assembly procedure, therefore, is very carefully planned so that oil is added to the compressor only after dehydration, or during this process. Temperatures are controlled to prevent "breathing," and the machine is promptly sealed after addition of the oil and refrigerant charge.

In service, it is just as important to add replacement oil under similar conditions. Fortunately, transportation air conditioning units do not require this procedure unless the machines are to be completely overhauled, when the work is done in the car repair shop, where care in handling is practicable. As uniform temperature is most important, it is advisable to store oil containers adjacent to the repair room, or to keep them therein for at least twenty-four hours before opening. This will reduce the possibility of moisture condensation when they are subsequently opened.



Courtesy of Carrier Corporation

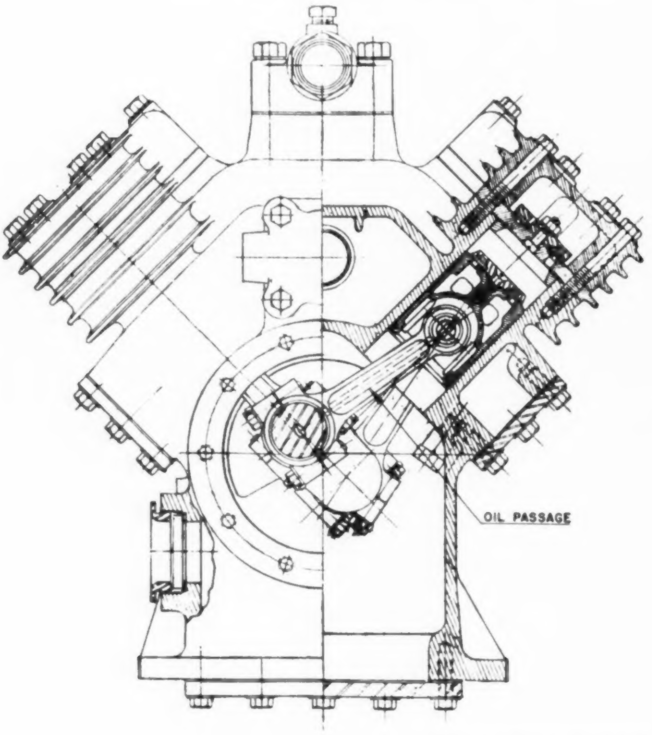
Fig. 7—The lubricating system of the Carrier "V" type air conditioning compressor as used in railway work. Note lubrication features as indicated.

Low Pour Test Precludes Congealment

The refrigerating engineer is also concerned with low pour test. Briefly, it indicates how low an oil can be chilled before it will become sluggish due to congealment. Air conditioning compressors do not operate at as low temperatures as refrigerators or food preservation units, so there is remote possibility of restricted oil flow due to increase in body. Even so, low pour is an important feature in bus or railway service, for atmospheric conditions may vary widely. Furthermore, low pour is an indication of adequate refinement and wax removal, although the pour test is also associated with the viscosity. In other words, increase in the latter will be paralleled by higher pour test. Here the observed pour test may be due to both the wax content and the viscosity, or to the viscosity alone; in the case of the latter, we are concerned with the "viscosity-pour". This is especially true of naphthenic base oils which

naturally contain a minimum amount of wax. Hence the preference for such oils for refrigeration or air-conditioning service.

Recent developments in refining procedure and solvent dewaxing have indicated, however, that it is practicable to start with a paraffin or mixed base crude, and arrive at a similar objective by using various combinations of refining and dewaxing, but the cost of the finished product may be somewhat increased. This is why segregation of crude stocks has become so important; it is a vital factor in the ultimate production of refrigeration oils which will stand operating temperatures as low as —60 degrees Fahr., and possess the maximum of stability under other conditions which might induce chemical breakdown.



Courtesy of Carrier Corporation

Fig. 8—End view of the Carrier "V" type compressor as designed for railway air-conditioning service.

THE DRIVE

The railway air-conditioning compressor can be driven by either one of two methods:

(1) Through belt or motor connection from one of the truck axles.

(2) By an auxiliary gasoline or propane engine, direct connected to the compressor.

The bus air-conditioning assembly, however, favors the auxiliary engine drive, the entire unit—engine plus compressor—being mounted on the same base and housed to protect it from road dust.

Such an engine may be installed either horizontally or vertically. The former enables location where less under-floor head room is available; of necessity, however, the assembly is longer than where a vertical engine is used. Adequate horsepower must be developed by the engine for the compressor drive, flexibility being advantageous where a wide atmospheric temperature range may prevail.

Four cylinder construction prevails in the engine used to drive the rotary vane compressor. This assembly is characterized by its light weight and the small size of the engine.

The Drive Engine

This unit, typical of the automotive gasoline engine, is applicable to both the bus and railway air-conditioning installation, although the fuel may differ, the former operating on gasoline, the latter on propane. In other respects, the service conditions are quite similar, the duty being comparable to the bus engine; hence the necessity for carefully refined lubricating oils to meet the temperature and load conditions. The former may be particularly intensive, due to the difficulty in providing for adequate ventilation and air cooling in the cramped housings. In some designs, this air must first pass through the condenser before it reaches the engine radiator.

Pressure lubrication predominates in the auxiliary gasoline or propane engine designed for air conditioning service. In this respect, there is an analogy to the heavy-duty bus engine which likewise employs full pressure to obtain the most dependable lubrication.

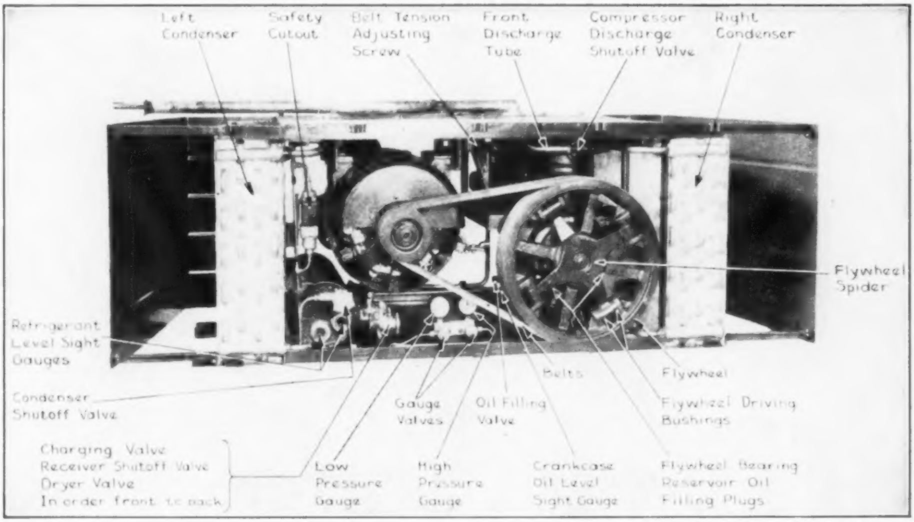
In this system, the oil is distributed under pressure to all engine bearings, including the main, connecting rod, camshaft, and piston pin elements. Pressure is favored for such service, because it delivers the maximum volume of oil to these parts. This, in turn, lends to better heat transfer by the cooling effect of this virtual flooding of the bearing clearances.

Cylinder lubrication, in turn, is brought about by the oil which escapes from the sides of the connecting rod bearings or from spray holes in the connecting rod. The rate of oil circulation depends upon the oil viscosity, the

pressure of delivery, and the bearing clearances. Oil pump design has been very carefully studied in order to provide greater capacity, to assure of delivery of sufficient oil to all parts of the engine, regardless of load conditions, temperature, or oil viscosity. In this way, the necessity for using heavier-bodied oils in worn engines is precluded; in other words, pump capacity is taking the place of viscosity as the factor in maintenance of sufficient pressure to maintain lubrication throughout the engine.

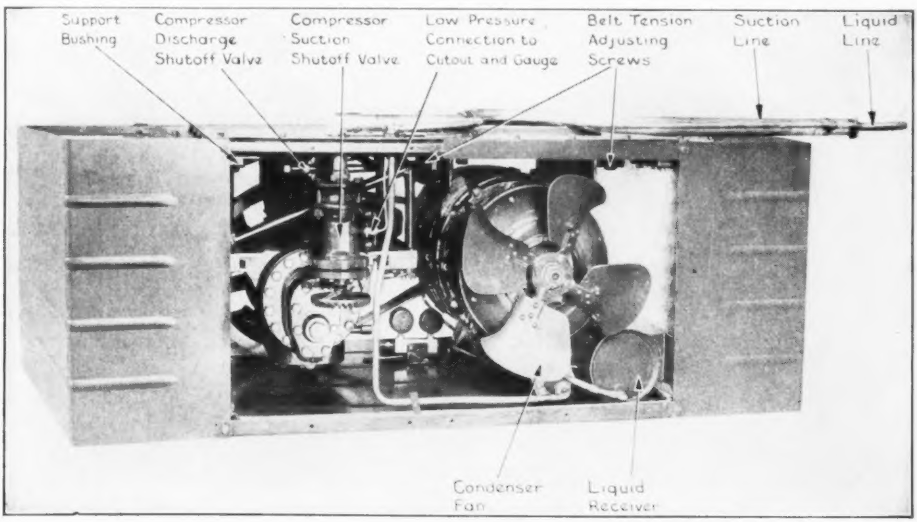
Improvements in engine cooling systems have also contributed to more dependable lubrication, likewise the trend towards lower clearances and better surface finishes.

All this is supplemented by the positive action of the gear type oil pump, which is so widely used in the modern automotive engine. It is simple in design, dependable in action, does not clog readily, and is free from pulsation. On the other hand, it tends towards lower volumetric efficiency when worn, and



Courtesy of General Electric Company

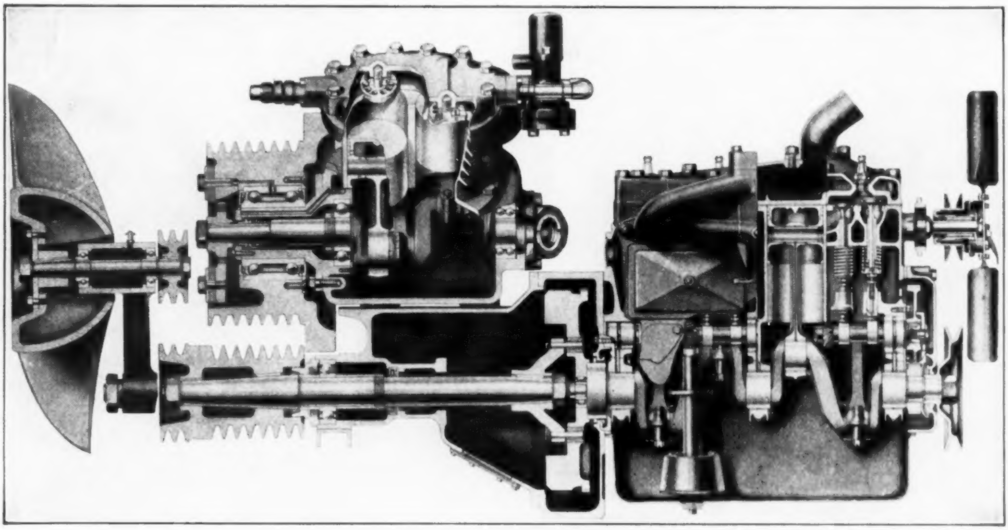
Fig. 9—The General Electric compressor-condenser unit for railway air conditioning service, with cover removed to show rear view of the various parts as indicated. With regard to lubrication, note the oil filling valve, the crankcase oil level sight gage, and the flywheel bearing reservoir oil filling plugs.



Courtesy of General Electric Company

Fig. 10—Front view of the General Electric compressor-condenser unit for railway air conditioning service, with cover removed to show the parts indicated.

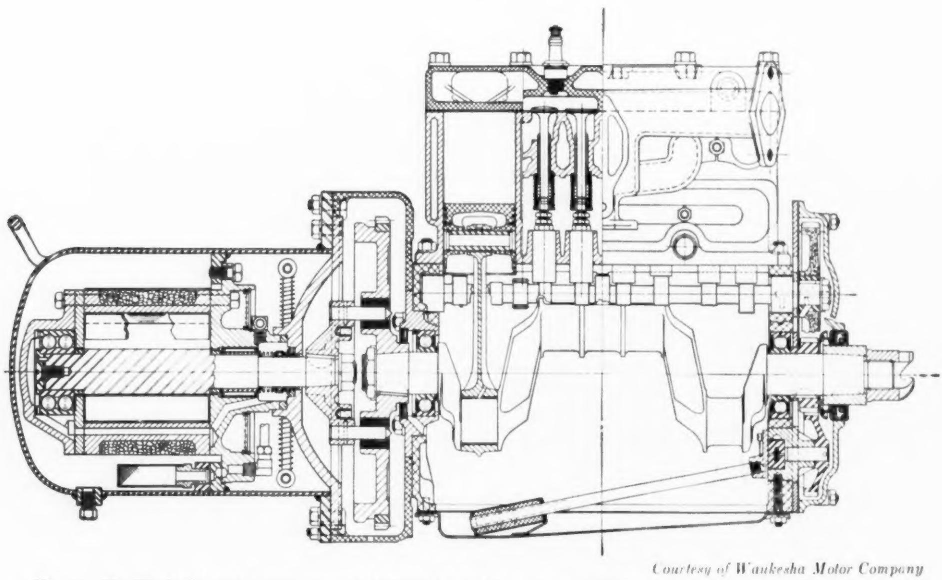
cannot develop very much suction lift. So the oil level must be carefully controlled by adequate makeup, according to the service conditions. Hard running obviously increases oil consumption.



Courtesy of Waukesha Motor Company

Fig. 11—The Waukesha Railway Ice Engine showing principal features of construction. This includes a four cylinder, propane fueled, internal combustion engine and a reciprocating type refrigerant compressor, connected by multiple "V" belts. Propane is delivered to the engine as a dry gas, so crankcase dilution and carbon deposits are reduced to a minimum. This extends the life and durability of the oil so that change is only necessary every three hundred and fifty hours.

Oil pressure, however, is not the final indication of proper engine lubrication. A low viscosity oil may indicate low oil pressure, still it may be circulating more rapidly through the bearing lubricating systems, thereby conveying away more heat than would a heavier oil, which would circulate more slowly, with lower heat transfer ability, yet the latter oil would show higher pressure. The higher the



Courtesy of Waukesha Motor Company

Fig. 12—The Waukesha engine-compressor as designed for mobile equipment service. Note constructional details, the ball bearing crankshaft, and cushion drive between the engine and compressor. The latter is a rotary ten-vane type, self-lubricated by pressure, and self-contained. The engine is a four cylinder, four cycle unit, also pressure lubricated.

viscosity, the greater the internal friction within the oil itself, a factor which contributes to higher engine temperatures.

viscosity. So it is usually best to choose the latter in the beginning for the reasons already outlined.

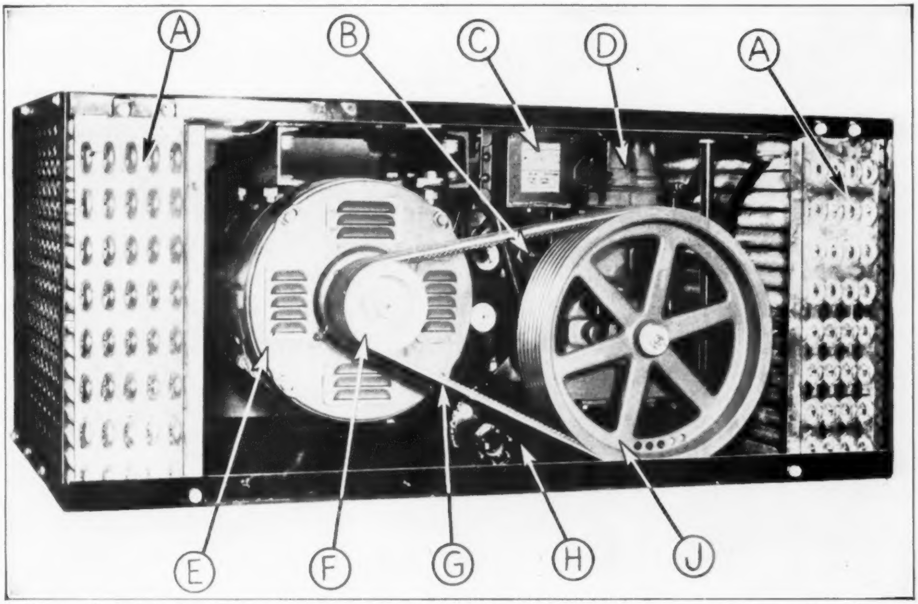


Fig. 13—Typical details of an electric drive refrigerating unit, showing at A—condenser assembly; B—suction valve; C—pressure cutout; D—compressor body; E—motor; F—motor pulley; G—belts; H—receiver assembly; and J—flywheel.

Automatically, the latter will reduce the viscosity of the oil to a point of so-called "equilibrium", comparable with a lower initial

BALL AND ROLLER BEARINGS

Grease lubrication is necessary for the compressor motor ball and roller bearings, the

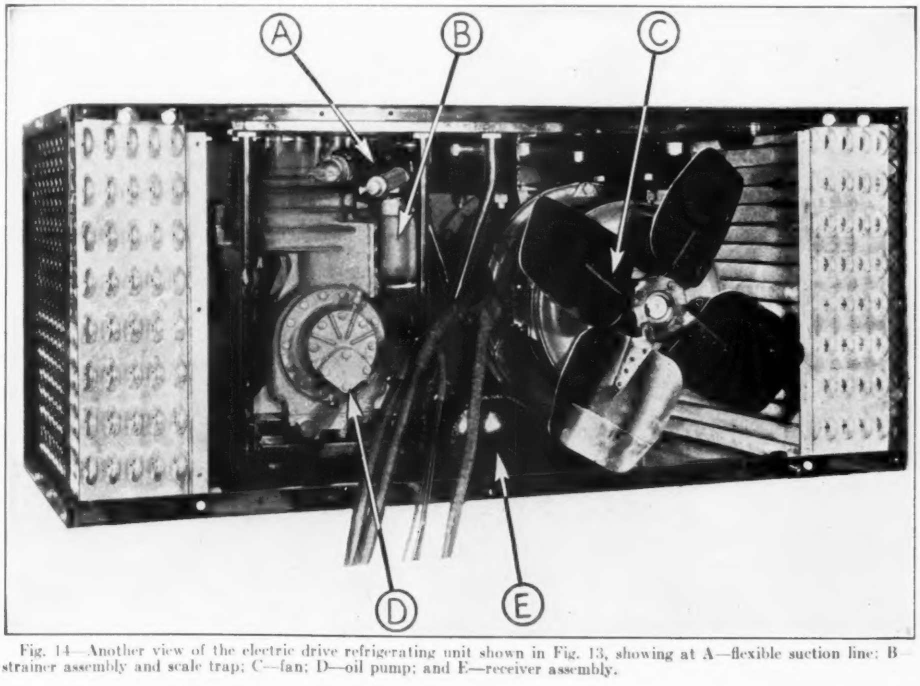
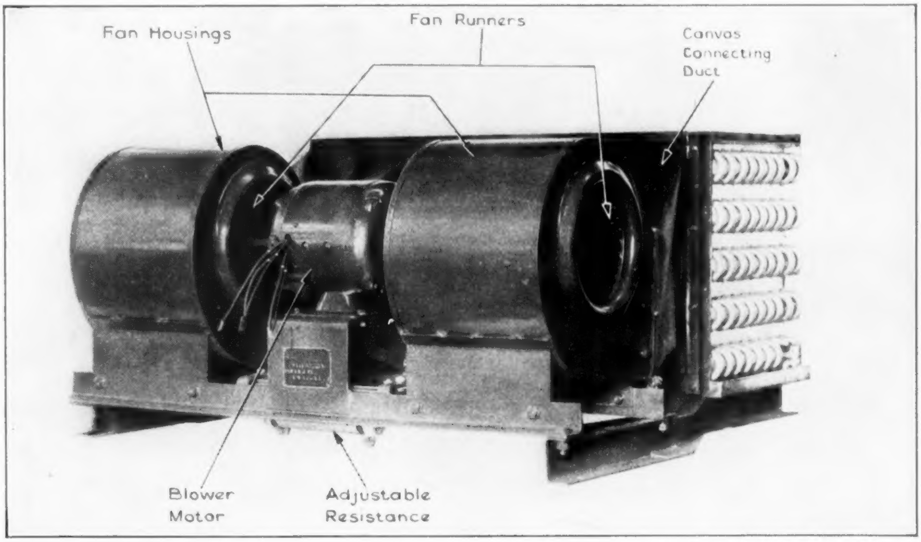


Fig. 14—Another view of the electric drive refrigerating unit shown in Fig. 13, showing at A—flexible suction line; B—strainer assembly and scale trap; C—fan; D—oil pump; and E—receiver assembly.

compressor drive pulley bearings, and similar elements on the motor cooling fan and air circulating fan. Ball bearings predominate, although some combination a.c. and d.c. motors will have a ball bearing on one end and a roller bearing on the other.



Courtesy of General Electric Company

Fig. 15—A General Electric evaporator unit for air-conditioning service of railway passenger cars. Oblique rear view showing motor and fan housings where lubrication of motor and fan bearings is required.

It has been found necessary to design these bearings so that they will be virtually dust proof, for they are continually exposed to track dust as it is swirled around with the suction caused by the train. Careful sealing protects the bearing elements quite satisfactorily, likewise lubrication, but renewal of lubricant is necessary at regular intervals. A high-melting point grease is used for this purpose.

Maintenance of ball bearings by adequate lubrication is a most important duty in the rolling stock department. It includes both the selection of replacement greases and formulating schedules for the cleaning, flushing, and relubrication of the bearings.

In selecting the grease, it is well to remember that it should be highly resistant to oxidation, free from acid-forming tendencies, non-corrosive, and free from fillers or non-lubricating materials. This requires the selection of only the purest ingredients in manufacture, and compounding in such a way as to assure of a finished product of uniform structure, which it will maintain under reasonable changes in temperature or conditions which might lead to oxidation. Such greases are available and noteworthy for their durability in long time service.

Mixed base or sodium soap greases are best suited to the conditions which prevail in railway ball bearing service on axle-driven units. Normally relubrication with such a grease is necessary only about twice a year, or, in some instances, only at the beginning of the cooling season. Meanwhile, both the grease and bearings are protected by carefully designed seals which effectively prevent leakage of lubricant or entry of abrasive dust or other foreign matter. Sodium soap greases or products of mixed base containing a combination of sodium and calcium soaps, can be used under comparatively high temperatures up to 25 degrees below their melting point, or momentarily at temperatures considerably above the latter. As the melting point is usually well above 250 degrees Fahr., a range rarely approached in axle drive units, undue fluidity or change in chemical structure are remote possibilities.

Relubrication procedure normally involves pressure-gun application. The modern ball or roller bearing is usually provided with a drain plug which can be removed at the time of relubrication for expulsion of old grease by the pressure developed by the gun. Removal of this plug is also recommended when more complete cleaning of the bearing elements is necessary by flushing with light mineral oil. Ball bearings in under-car railway service are exposed to so much track dust that even with the best of seals, some minute particles may penetrate to the interior. But a few particles of abrasive material are necessary to cause rough rolling and scoring of the race or ball surfaces.

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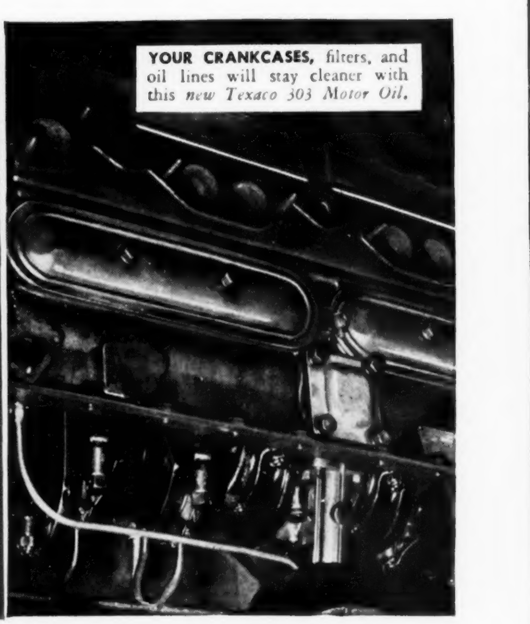

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